Near-optimal atom-photon interfaces in the solid-state

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Today, optical quantum technologies are limited both by the low efficiency of heralded single-photon sources and by the probabilistic operation of two-photon gates. Deterministic sources and gates can in principle be obtained making use of the single-photon sensitivity of an atomic transition. In this context, artificial atoms in the form of semiconductor quantum dots have emerged as a promising system to scale up optical quantum technologies, offering the potential of integration and scalability.

In this talk, we will review our recent progresses along this research line. We will discuss how a single quantum dot can be positioned in an optical cavity in a fully controlled way, so as to control its spontaneous emission on demand [1-2]. Close to ideal atom-photon interfaces are obtained, where a single quantum dot interacts with a single mode of the optical field and is largely isolated from all sources of decoherence [3].
These systems are shown to be bright single-photon sources with single photon purity and indistinguishability exceeding 99%. The brightness of the sources exceeds by a factor 20 the one of currently used sources based on parametric down conversion [4-5]. We have also made progresses toward the development of deterministic two-photon gates [6], with devices performing as nonlinear switches at the single-photon level, converting a coherent pulse into a highly non-classical light wave-packet [7].

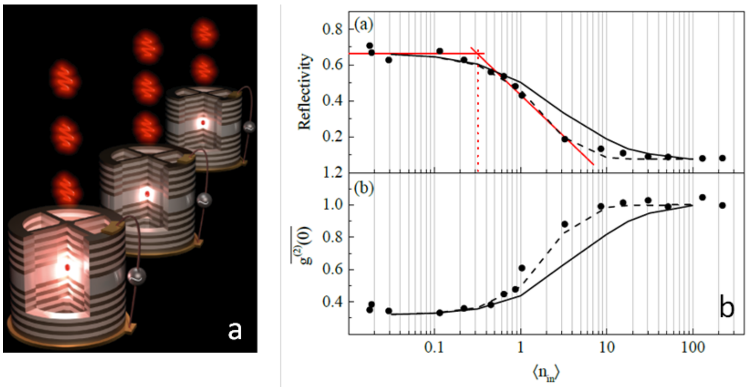

Fig. 1: (a) Artist view of the quantum-dot cavity devices performing as near optimal atom-photon interfaces. (b) Reflectivity (top) and second order intensity correlation function (bottom) of the directly reflected light as a function of the incident photon number (pulsed excitation).

References

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